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XXX. *On a new Method of preparing a Test Liquor to shew the Presence of Acids and Alkalies in chemical Mixtures. By Mr. James Watt, Engineer; communicated by Sir Joseph Banks, Bart. P. R. S.*

Read May 27, 1784.

THE fyrop of violets was formerly the test of the point of saturation of mixtures of acids and alkalies, which was principally used; but since the late improvements in chemistry it has been found not to be sufficiently accurate, and the infusion of tournesol, or of an artificial preparation called litmus, have been substituted in the place of it.

The infusion of litmus is blue, and becomes red with acids. It is sensible to the presence of one grain of common oil of vitriol, though it be mixed with 100000 grains of water; but as this infusion does not change its colour on being mixed with alkaline liquors, in order to discover whether a liquor be neutral or alkaline, it is necessary to add some vinegar to the litmus, so as just to turn the infusion red, which will then be restored to its blue colour, by being mixed with any alkaline liquor. The blue infusion of litmus is also a test of the presence of fixed air in water, with which it turns red, as it does with other acids.

The great degree of sensibility of this test would leave very little reason to search for any other, were there reason to believe that it is always a test of the exact point of saturation of

acids and alkalies, which the following fact seems to call in question.

I have observed, that a mixture of phlogificated nitrous acid with an alkali will appear to be acid, by the test of litmus, when other tests, such as the infusion of the petals of the scarlet rose, of the blue iris, of violets, and of other flowers, will shew the same liquor to be alkaline, by turning green so very evidently as to leave no doubt.

At the time I made this discovery, the scarlet roses and several other flowers, whose petals change their colour by acids and alkalies, were in flower. I stained paper with their juices, and found that it was not affected by the phlogificated nitrous acid, except in so far as it acted the part of a neutralizing acid; but I found also, that paper, stained in this manner, was by no means so easily affected by acids of any kind as litmus was, and that in a short time it lost much of that degree of sensibility it possessed. Having occasion in winter to repeat some experiments, in which the phlogificated nitrous acid was concerned, I found my stained paper almost useless. I was, therefore, obliged to search for some substitute among the few vegetables which then existed in a growing state; of these I found the red cabbage (*brassica rubra*) to furnish the best test, and in its fresh state to have more sensibility both to acids and alkalies than litmus, and to afford a more decisive test, from its being naturally blue, turning green with alkalies, and red with acids; to which is joined the advantage of its not being affected by phlogificated nitrous acid any farther than it acts as a real acid.

To extract the colouring matter, take those leaves of the cabbage, which are freshest, and have most colour; cut out the larger stems, and mince the thin parts of the leaves very small; then digest them in water, about the heat of 120 degrees, for

a few hours, and they will yield a blue liquor, which, if used immediately as a test, will be found to possess great sensibility. But, as this liquor is very subject to turn acid and putrid, and to lose its sensibility, when it is wanted to be preserved for future use the following processes succeed the best.

1. After having minced the leaves, spread them on paper, and dry them in a gentle heat; when perfectly dry, put them up in glass bottles well corked; and when you want to use them, acidulate some water with vitriolic acid, and digest, or infuse, the dry leaves in it until they give out their colour; then strain the liquor through a cloth, and add to it a quantity of fine whiting or chalk, stirring it frequently until it becomes of a true blue colour, neither inclining to green nor purple; as soon as you perceive that it has acquired this colour, filter it immediately, otherwise it will become greenish by longer standing on the whiting.

This liquor will deposit a small quantity of gypsum, and by the addition of a little spirit of wine will keep good for some days, after which it will become a little putrid and reddish. If too much spirit is added, it destroys the colour. If the liquor is wanted to be kept longer, it may be neutralized by means of a fixed alkali instead of chalk.

2. But as none of these means will preserve the liquor long without requiring to be neutralized afresh, just before it is used; and as the putrid and acid fermentation which it undergoes, and perhaps the alkalies or spirit of wine mixed with it, seem to lessen its sensibility; in order to preserve its virtues while it is kept in a liquid state, some fresh leaves of the cabbage, minced as has been directed, may be infused in a mixture of vitriolic acid and water, of about the degree of acidity of vinegar; and it may be neutralized, as it is wanted, either by means of chalk,

or

422 *Mr. WATT's Method of preparing a Test Liquor, &c.*

or of the fixed or volatile alkali. But it is necessary to observe, that if the liquor has an excess of alkali, it will soon lose its colour, and become yellow, from which state it cannot be restored; therefore care should be taken to bring it very exactly to a blue, and not to let it verge towards a green*.

3. By the same process I have made a red infusion of violets, which, on being neutralized, forms at present a very sensible test; but how long it will preserve its properties I have not yet determined. Probably the coloured infusions of other flowers may be preserved in the same manner, by the antiseptic power of the vitriolic acid, so as to lose little of their original sensibility. Paper, fresh stained with these tests in their neutral state, has sufficient sensibility for many experiments; but the alum and glue which enter into the preparation of writing-paper seem in some degree to fix the colour; and paper which is not sized becomes somewhat transparent, when wetted, which renders small changes of colour imperceptible; so that where accuracy is required, the test should be used in a liquid state†.

* Since writing the above, I have found, that the infusions of red cabbages and of various flowers in water acidulated by means of vitriolic acid, are apt to turn mouldy in the summer season, and also that the moulding is prevented by the addition of spirits of wine. The quantity of spirit which is necessary for this purpose I have not been able to ascertain; but I add it by little at a time, until the progress of the moulding is prevented.

† I have found, that the petals of the scarlet rose, and those of the pink-coloured lychnis, treated in this manner, afford very sensible tests.

